Pacific Ocean Connections:
Priorities for Pelagic Fisheries Research in the Twenty-first Century
Report of PRFP Research Priorities Workshop
November 16-18, 2005

John Sibert, Scott McCreary, & Eric Poncelet

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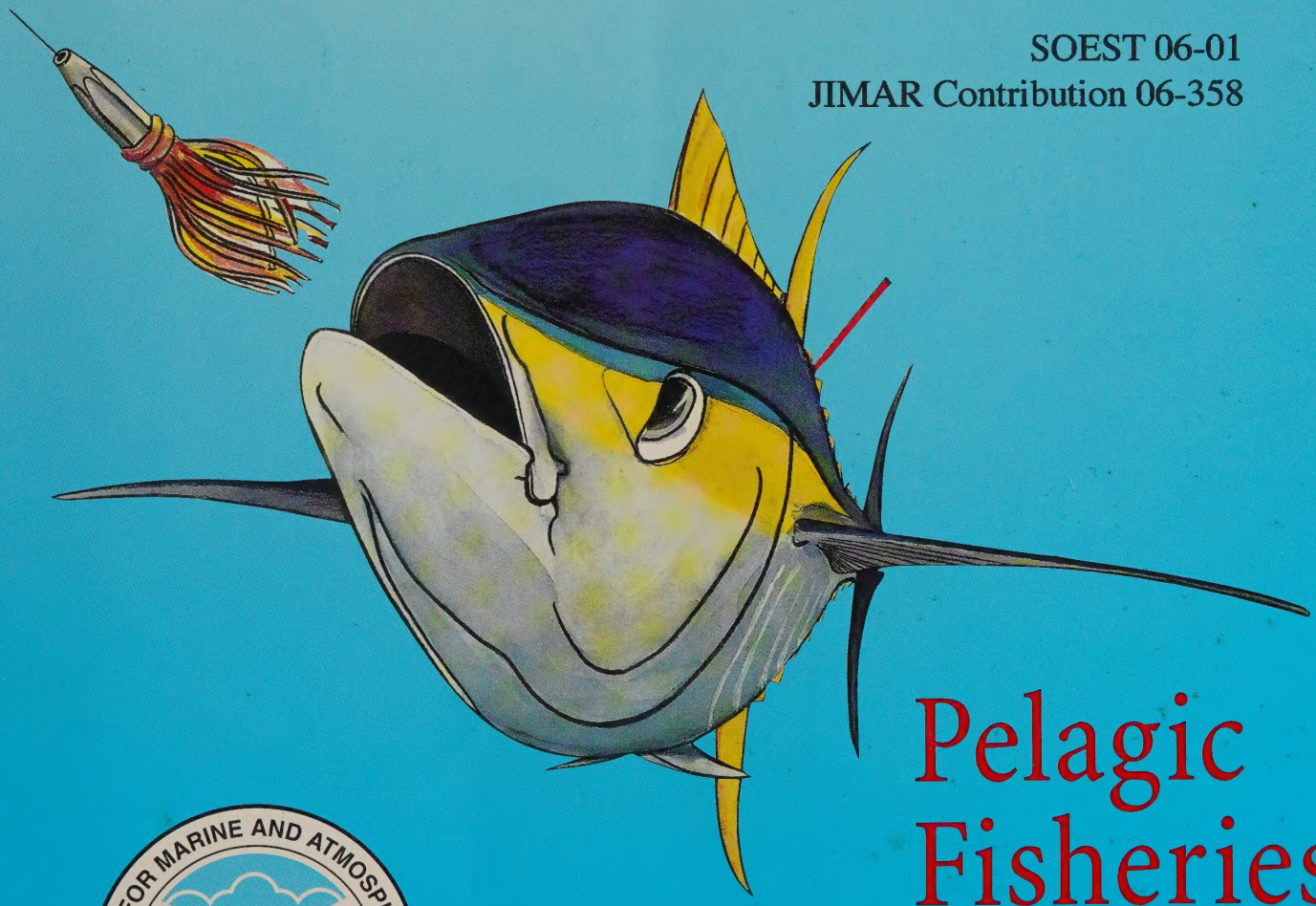

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Executive Summary

The Pelagic Fisheries Research Program (PFRP) is a federally funded research program at the University of Hawaii (UH) that was created in 1992 to enhance the scientific basis for management of fisheries for highly migratory species in the western Pacific region. An international group of scientists and fishery managers gathered for two and a half days in Honolulu in November 2005 to discuss future research priorities for the PFRP. The Workshop opened with invited presentations from representatives of fisheries research and management organizations in the Pacific, outlining their visions of research priorities. Workshop participants convened in small discussion sessions to identify and rank research topics in four general areas: applied economics, ecosystem integration, biology and life history, and fishing communities. The highest ranking individual topics in each general area were:

- Develop flexible economic models of fisheries;
- Evaluate the trophic impact of large removals of selected species from the ecosystem;
- Support large-scale tagging programs to investigate movement on different scales;
- Determine sources, distribution, and uses of fish in fishing communities.

The priority topics identified by the breakout groups were discussed in plenary session and several "cross-cutting" issues were identified. Development of fisheries research capacity in the Pacific basin in both developing and developed countries was recognized as a prerequisite to fisheries management. The PFRP assists in developing research capacity through collaboration with other institutions and through support of a degree granting program at the University of Hawaii. Workshop participants explored the notion of "flagship" projects that would encompass several high priority research topics and which might attract funding from additional sources.

There was consensus that while research in support of management for highly migratory fish stocks is most appropriately conducted using a basin-scale approach, many fishery management problems may require more local approaches. At all scales, understanding of the pelagic ecosystem and its human constituents is fundamental for sound fishery management decisions.

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1. Background

Scientific support of fishery management must be carefully tuned to management issues. Fishery research organizations periodically review their research priorities. In 1984, the Inter-American Tropical Tuna Commission (IATTC) convened a workshop to update the Commission's research priorities in response to changes in the fishery. The workshop identified three topics for priority attention—tuna movement and distribution, periodic variation in chemical constituents in relation to ageing, stock heterogeneity and transfer rates, and genetic heterogeneity (Joseph and Wild, 1984).

The PFRP operates under research priorities established in a March 1992 workshop (Ianelli, 1992). The 1992 workshop emphasized local research topics such as economic analysis of the Hawaii longline fleet and potential impacts of large-scale commercial fisheries on small-scale fisheries operating within the United States exclusive economic zone (EEZ). Larger issues such as stock structure, basic fisheries, and biological data collection, and stock assessment were also flagged as high priority topics. These topics were extended and formalized in a coherent model for conducting research in support of managing fisheries for highly migratory fish species (Sibert, 2000).

Although the 1992 priorities have been useful, fishery management concerns, international governance arrangements, and the fisheries themselves have changed radically. Since 1992, the ecosystem approach to fisheries has become the dominant paradigm for twenty-first century fisheries management. The Western and Central Pacific Fisheries Commission (WCPFC) began operations in 2004, thereby establishing an international fishery management regime to regulate the largest unregulated tuna fishery in the world. Purse seine fisheries for tropical tunas have expanded throughout the equatorial Pacific pushing the annual yield in the western and central Pacific Ocean above 2 million metric tons. The goal of the 2005 Workshop was to update these research priorities to assure the continuing fishery management relevance of PFRP-sponsored research.

2. Organization of Workshop

PFRP Manager John Sibert convened the workshop and a Steering Committee comprised of Craig Severance (Dept. of Anthropology, UH-Hilo), Keith Bigelow (National Marine Fisheries Service, Pacific Islands Fisheries Science Center), and Paul Dalzell (Western Pacific Regional Fishery Management Council) assisted with planning. Scott McCreary and Eric Poncelet of CONCUR, Inc. facilitated the workshop.

The workshop was organized around three activities.

1. Invited presentations from fisheries research and management institutions with responsibilities in the Pacific Ocean (morning of November 16).
2. Breakout session discussions and ranking of potential pelagic fisheries research topics (afternoon of November 16 and morning of November 17).
3. Reporting breakout session outcomes followed by plenary discussion of ranking results and crosscutting themes (afternoon of November 17 and morning of November 18).

3. Participation in the Workshop

Workshop participation was open to anyone with an interest in fisheries for highly migratory species. It was publicized on the PFRP web site, in the PFRP Newsletter, on the UH and School of Ocean and Earth Science and Technology calendars, and by specific invitation. The Priorities Workshop was timed to immediately follow the annual PFRP Principal Investigators Workshop on November 14 and 15. About 55 people participated in the Priorities Workshop, with participants from the natural sciences outnumbering those from the social sciences. Biology was the dominant discipline represented. Some disciplines, such as genetics, were not well represented. To some extent, the priorities identified by the workshop reflect the interests of the participants. A list of participants is included in Appendix C.

4. Invited Presentations from Fisheries Research and Management Institutions

4.1. Western Pacific Regional Fishery Management Council (WPRFMC), Honolulu

Lines on the Ocean: Information Needs for Pelagic Fishery Management in the Western Pacific Region, Kitty Simonds, Executive Director, Western Pacific Regional Fishery Management Council

The WPRFMC (or "Council") operates under several domestic United States statutes. The principal statute, the Magnuson-Stevens Act, requires that Fishery Councils address ten National Standards when they develop fishery management plans (FMPs). Addressing the National Standards requires a diverse array of data and information that cut across social, economic and scientific disciplines. In addition, FMPs must be consistent with other US statutes concerned with impacts to the environment and protected species. Addressing these additional statutes also carries with it a substantial need for data and information to assist Council decision-making. The PFRP provides information to assist the WPRFMC in developing management policies to address several of the Council's current concerns. The recent establishment of a new regional fishery management organization in the western and central Pacific has highlighted the need for greater Council involvement in international pelagic fisheries management. Allocation of fishery resources, both at the domestic and international level, is an increasing preoccupation of the Council as more lines are drawn on the ocean to demarcate ownership and jurisdiction over Pacific pelagic resources.

4.2. National Oceanic and Atmospheric Administration (NOAA) Pacific Islands Fishery Science Center (PIFSC), Honolulu

NOAA Fisheries Research and Mandates Concerning Pelagic Fisheries in the Pacific, Samuel Pooley, Director, Pacific Islands Fishery Science Center

The past ten years have seen substantial changes in the context in which NOAA Fisheries' PIFSC does its research and how NOAA Fisheries conducts conservation and management activities related to pelagic species. These changes include biological, economic, and institutional factors of which some of the central ones are:

- increasing scope of responsibility, including geographical range and an ecosystem focus;
- the new role of litigation in governing conservation and management science;
- over-fishing of bigeye and yellowfin tuna in the Pacific and albacore in the North Pacific;
- increasing significance of oceanographic and ecosystem dynamics in fisheries assessments;
- continuing importance for understanding fishermen's and regulators' behaviors;
- environmental assessments in both research and conservation/management;
- reducing and mitigating interactions with protected species such as sea turtles, sea birds, and marine mammals and by-catch of other species such as sharks;
- cooperative research with industry;
- ebbs and flows in local and high seas commercial fisheries and attention to recreational fisheries;
- new international fisheries arrangements including the institutionalization of scientific advice.

Yet probably the biggest change is simply the change in the institutional context of PIFSC itself from a satellite laboratory associated with a mainland regional research center to a regional center for marine science in the central Pacific in its own right.

4.3 National Research Institute of Far Seas Fisheries, Shimizu, Japan

Pacific Bluefin Tuna, Treasure Box for Scientific Studies or Pandora's Box? Ziro Suzuki, Director, Pelagic Fisheries Resources Division

Five major topics important for research and management of Pacific bluefin tuna stock were described. They include:

- early life study for the purpose of better understanding of survival process;
- difference in size of fish for spawning and its implication on estimation of reproductive potential and stock structure;
- migratory pattern, which closely resembles that of the Atlantic bluefin tuna;
- effect of farming and complete aquaculture on the fisheries, management and economy;
- high dependency of the fisheries on juveniles.

These bluefin-specific issues are easily extended to general issues applicable to the management of fisheries for other species of tuna.

4.4 Inter-American Tropical Tuna Commission (IATTC), La Jolla, California

Some Research Ideas to Support Management of Eastern Tropical Pacific Tuna and Billfish Fisheries, Richard B. Deriso, Chief Scientist, Tuna-Billfish Program

Research issues for the Eastern Pacific Ocean (EPO) were related to issues identified at the PFRP Planning Workshop in 1992. The comparison shows that many of the issues

identified back in 1992 are still important research issues throughout the Pacific Ocean. Issues selected from the 1992 meeting's fisheries oceanography/biology working groups included stock structure, fish movement, habitat definition, behavior and other responses to changes in habitat/environment, reproductive dynamics, schooling patterns, and food chain ecology.

Each of the issues was related to both the most recent 2003 PFRP Request for Proposals as well as current research issues in the EPO. The first two, stock structure and fish movement, are not contained in the 2003 PFRP document but have been important in the past (see tuna aggregation below). The IATTC's current interest in stock structure covers all billfish species and emphasizes the need for further genetic studies. The IATTC's focus on the movement of tropical tunas centers on the need for Pacific-wide conventional and archival tagging study that is multi-year and concurrent in the east and west Pacific continuously across the Pacific for bigeye tunas (BET), primarily, and secondarily for skipjack (SKJ) and yellowfin tunas (YFT). As a prerequisite, an experimental design for the study is needed.

On the issue of behavior and other responses to changes in habitat/environment, a current focus for the PFRP is the dynamic of tuna aggregation (covered later in the discussion on tuna aggregation). The IATTC's current concern is estimating the effectiveness of the longline fishing effort, which anchors bigeye and yellowfin tuna assessments. Present habitat-based methods are now generalized to statistical habitat weightings for effort estimates but more research is needed to improve the method. A number of research questions are relevant to the behavior and habitat topics. Will better tagging data improve the empirical estimates? Can estimates of ocean sheer improve estimates? Can effective purse seine fishing effort be estimated? Is the "habitat" for fish aggregating devices (FADs) simply temperature and current driven? What other features define "habitat"? Where are tunas in relation to environment for dolphin-associated and free school fisheries? Are eddies and fronts important structures? How do we incorporate them in testable models?

Other responses to the environment include its effect on recruitment. Laboratory experiments show turbulence is an important factor in the survival of yellowfin tuna larva. How do we translate the lab result into a testable hypothesis in our assessment models? There is some suggestion of correlation in year-class strength between YFT, SKJ, and BET but at staggered lag times. Is this an environmental effect? How can this be tested? Does having information about factors affecting recruitment aid management?

On the topic of reproductive dynamics, a number of issues arise. Is spawning stock size important? Current reference points emphasize the relation of current spawning biomass to biomass that produces maximum sustainable yield (MSY); but that relation is largely dependent on the "steepness" of the relationship of recruits to spawners. What is the steepness of the relation? Does steepness (or carrying capacity) change over time? Are all eggs equal? How variable is recruitment? Are growth rates year-class specific?

With regard to schooling patterns, a major area of PFRP current interest is the dynamics of tuna aggregation. The IATTC's interest lies in areas related to "schooling patterns." Research is needed on fine-scale and temporal dynamics of SKJ schooling behavior around FADs in order to find differences in their behavior with other tunas, especially BET, in order to find opportunities to catch SKJ without BET and other non-target species. Research on FAD association through acoustic detection of BET, SKJ,

and YFT separately in order to provide species specific estimates of abundance and as a potential technique to aid the avoidance of BET. Research on the association between dolphins to YFT has been a long-standing priority of the IATTC. Passive Integrative Transponder (PIT) tagging may provide an opportunity for multiple measurements of dolphins in the back-down channel. Such research could help address numerous questions regarding school fidelity, interaction with the fishery, home range, and migration. Could the PIT tagging technique also be used for tuna?

The issue of food chain ecology has been broadened to consider ecosystem-based fishery management and ecosystem modeling, which is a priority research area for PFRP. Current research at the IATTC in collaboration with a PFRP funded project to compare food webs in the EPO to the central and western Pacific Ocean, define trophic structure, detect large-scale tuna movement, and define ecosystem linkages. There is a need for integration of ecosim-type models with current management to begin to quantify the effect of current management measures on future ecosystem structure. For example, research could be done on how single-species reference points work when placed in an ecosim model to empirically alter them to reduce ecosystem effects (e.g., trophic cascading).

An important part of ecosystem studies is the effect of tuna fisheries on protected species. Research on adaptation of integrated statistical models, such as those for fisheries, to protected species is in progress through a PFRP and IATTC collaborative project. One lesson learned from this study and other experiences is the need to educate more scientists on modern methods through collaborative studies and teaching of short courses. We need to further provide opportunities for interaction with scientists who may not have an extensive quantitative background to help them do the kinds of analyses that will further our knowledge of by-catch species dynamics.

4.5 Secretariat of the Pacific Community (SPC), Noumea, New Caledonia

Oceanic Fisheries Programme Strategic Plan 2006-2008, John Hampton, Programme Manager, Secretariat of the Pacific Community, Oceanic Fisheries Programme (SPC, OFP)

The tuna fishery in the western and central Pacific Ocean has expanded greatly in the past 30 years and currently has an annual catch of nearly 2,000,000 tonnes. Purse seine is the dominant fishing method, with significant catches by longline and pole-and-line. Skipjack is the main species caught, with significant catches of yellowfin, bigeye and albacore. Skipjack and albacore (South Pacific stock) are considered to be currently fished at sustainable levels but recent assessments of bigeye and yellowfin indicate that overfishing of these stocks is likely.

The Oceanic Fisheries Programme of SPC conducts fishery monitoring, stock assessment and biological and ecological research on the fishery. Its objectives are focused on fishery monitoring, stock assessment and ecosystem monitoring and research. Currently, the main research priorities of the OFP are development and improvement of stock assessment methods (including model development and estimation of abundance indices from longline fisheries), tuna tagging for provision of information for stock assessment and the impact of FADs on fish movement and behavior, and ecosystem research with a focus on modeling and trophic relationships.

The OFP has been developing plans for a new regional tuna tagging project, the first phase of which is likely to be undertaken in Papua New Guinea (PNG) in 2006-2007. The focus of the work in PNG is the estimation of local exploitation rates of skipjack, bigeye, and yellowfin tuna and the small-meso-scale behavior of these species, in particular their vertical and horizontal movements, in relation to anchored FADs, which have been deployed in high density arrays throughout northern PNG, and seamounts. The PFRP was invited to participate in this work, and in the second phase of the project in other areas of the western and central Pacific, through the development of joint proposals for funding of particular aspects of the work.

5. Breakout Session Discussions and Ranking of Potential Pelagic Fisheries Research Topics

The workshop included four, half day breakout sessions. The primary objective of the breakout sessions was to identify and prioritize research topics in four general research areas. Workshop participants were invited to participate in either the applied economics or the ecosystem integration breakout sessions on Day 1, and either the biology and life history or the fishing communities breakout sessions on Day 2. Each attendee participated in two of the four breakout sessions. The breakout session topics and the three top-ranking research priorities are listed below.

1. Applied economics: economics applied to the development of fishery management policy.
   - Investigate broad range of economic models of fisheries.
   - Use economic tools to examine constraints on indigenous fisheries.
   - Identify a comprehensive ecosystem framework for economic analysis that integrates with biological and physical models.
2. Ecosystem integration: including a focus on the areas of incidental catch and protected species, ecosystem delineation and indicators, oceanography, and modeling.
   - Evaluate large-scale trophic interactions, such as removals of specific tuna species, with the goal of addressing the impact of fishing on ecosystems.
   - Determine effects of FADs on local and wider-scale ecosystems and on pelagic fish production.
   - Study movement to define functional sizes of ecosystem units.
3. Biology and life history: application of biology and life history studies to the development of fishery management policy.
   - Support development of a major international tagging program.
   - Investigate trophic ecology of tuna and related species.
   - Investigate physiology of tuna and related species to improve understanding of energetics and parameterization of ecological models.
4. Fishing communities: informing fisheries management through understanding of fishing communities.
   - Determine fish flow—sources, distribution channels, quantities, end use and cultural value in fishing communities.
   - Study stakeholder and public perceptions of condition of pelagic fisheries and their impacts on marine ecosystems.

- Contextualize fishery data in terms of ecological, economic, political, and technological history.

The organization and flow of the breakout sessions is fully described in Appendix A and the complete ranked lists of research priorities are presented in Appendix B.

6. Plenary Discussions

Breakout session moderators reported the results of the brainstorming and ranking activities to the full plenary. Workshop participants were asked to review the topics that received many or few votes, note particular topics that were missing from the lists, comment on areas of overlap and crosscutting themes, and discuss possible implications for the PFRP. Participants were also asked to reflect on which of the candidate research topics were of greatest relevance to fishery managers.

6.1 Addressing Fishery Management Needs

6.1.1 Specific research topics of high priority for fishery management

Breakout session moderators and participants were invited to identify the research topics that they viewed as being of greatest relevance for addressing fishery management issues. Research topics of importance to fishery management:

1. Applied economics
   - General: Fishery managers would benefit from more rapid turn-around times for all applied economics research topics. Participants in the applied economics breakout group identified provision of timely data in "template formats" as a high priority topic (4b). The data standards and data distribution networks required to address this topic have not yet been established.
   - Participants in the applied economics breakout group identified exploration of a broad range of economic models to identify efficient methods for evaluating policy choices as the highest priority topic. These models need to be easily applied to management situations and easily updatable as new data are collected.
2. Ecosystem integration:
   - Determine effects of fish aggregating devices (FADs) on local and wider-scale ecosystems and on pelagic fish (topic 2).
   - Topic 5, carry out ecosystem/multi-species management strategy evaluation, potentially including data collection, control rules, monitoring, and assessment methods and topic 6a, determine the influence of meso-scale oceanography (fronts, eddies, seamounts) on ecosystems. Both topics are of high priority to fisheries managers with respect to protected species.
   - Topic 4c, improve stock assessment methods, is particularly important to ecosystem integration because the ecosystem approach requires more information on effects of fisheries on non-target species.
3. Biology and life history
   - Topic 6, support investigations to improve understanding of associations between tunas and other marine animals, including studies of whale sharks and cetaceans.

- Topic 7, support investigation of early life history of tuna and other sensitive marine species, is particularly relevant to development of closed areas as a management tool.
- Topic 9, support of investigations to improve understanding of behavior with respect to fishing to improve targeting.

4. Fishing communities
   - Topic 1, determine fish flow, including sources, distribution channels, quantities, and end use (including cultural value).
   - Topic 3, contextualize fishery data (catch, catch per unit of effort [CPUE], bycatch) in terms of social (e.g., culture), ecological (e.g., storms), economic/ market, and political and technological history.
   - Topic 4c, study at-sea fleets as communities (including expert knowledge and fishery behavior). Participants noted that at any moment there are a large number of people at sea making a range of observations pertinent to the state of the ecosystem. Discussions on this topic focused on how to engage this community to optimize time at sea by avoiding areas of high bycatch and to assist in research efforts.
   - Topic 5, assess impacts of past and current regulations on fishermen and associated communities and determine whether such impacts can be predicted for future regulations.

6.1.2 What is the appropriate scale of pelagic fisheries research?

Participants discussed biological and economic/social research topics with a wide range of scales. Participants saw linkages between the different scales (i.e., wider trends can affect local trends, and vice versa). Several issues (e.g., climate change) were also seen as inherently operating at multiple scales.

Many fishery management problems are inherently local in scale. Research to find solutions clearly need to be conducted on the appropriate scale. Nevertheless, there was general agreement among participants that many of the research topics identified at the workshop should be appropriately addressed at ocean-basin scale.

6.1.3 Receiving timely information/data—Getting ahead of the curve

Workshop participants discussed the critical need for research to be of service to management. The research procurement process typically takes several months to complete and the research itself may take several years to produce results. Well-designed research projects are therefore critical to "getting ahead of the curve" in anticipating future fishery management issues.

Participants identified the following strategies for getting ahead of the curve:

- Focus research on a basin-wide level.
- Broaden the timeframe of analysis of pelagic fishery issues, both backward and forward.
  - Participants showed a keen interest in evaluating the impacts/implications of past resource management decisions.
  - Participants also showed a keen interest in anticipating future issues, including engaging in model/scenario building.
- Build the capacity for conducting science and fishery management beyond the main Hawaiian Islands.
- Keep an eye on potential future "hot-button" issues such as the following.
  - Future demand for pelagic fish.
  - Future human population growth.
  - Growing markets in key countries, e.g., China.
  - Climate change.

7. Crosscutting Themes

Participants were asked to comment specifically on research themes that they saw as cutting across disciplinary boundaries.

7.1 Build Research Capacity in the Pacific Basin

Participants viewed building research capacity among Pacific Basin states, territories and nations as a major priority. Participants also acknowledged that a basin-wide frame of analysis increases the need for the PFRP to build on relations with other research institutions. Participants expressed interest in sub-regional cooperation among the PFRP, IATTC, WCPFC, SPC, and other research institutes in countries such as Japan.

Participants agreed that the PFRP should have an active role in development of the planned fisheries degree program at the University of Hawaii. Financial support of graduate students at the University of Hawaii and other Pacific Basin universities is a vital aspect of this role and essential for the long-term maintenance of research capacity in the Pacific Basin.

7.2 Identify and Support "Flagship" Projects

Participants discussed the potential benefits of establishing PFRP "flagship" projects that might serve as a focus for funding. Flagship projects could serve as vehicles to address multiple research priorities. Participants also highlighted the connections that exist across research topics. Participants discussed a number of potential flagship projects including the following.

7.2.1 Focus on tagging programs

Tagging programs, using a suite of tagging and data analysis methods, provide information on movement at different scales, direct estimates of fishing mortality, and a detailed understanding of behavior. Tagging programs also engage fishing communities

though fisher involvement in tag release and recovery. There was strong interest in having the PFRP support comprehensive tagging programs. Due to the high cost (and potentially large scale) of tagging programs for pelagic species, participants did not envision the PFRP operating alone in this arena but rather in cooperation with other research institutions. Potential PFRP roles could include the following.

- Support add-on projects.
- Support investigations of optimal experimental design for tagging programs.
- Support workshops on tagging.
- Serve as planner and coordinator of experiments in the Pacific Basin.
  - Work with IATTC and the OFP.
  - Solicit funding from multiple sources.
  - Pursue coordinated sub-regional approaches.
- Support new tagging techniques and technologies.
- Support tagging research on a sub-regional scale.
- Integrate private/recreational tagging efforts (work with social scientists).

7.2.2 Focus on fishing communities

A second potential flagship topic focuses on fishing communities and their role in fishery management, marketing, and markets. Participants recommended that potential research projects focus on a diversity of temporal and geographic scales. Potential PFRP roles could include the following.

- Coordinating linked fishing communities projects.
- Coordinating or building consortia among groups of social scientists and de facto experts (e.g., recreational fishers).

7.2.3 Focus on ecosystems

A third recommended flagship topic focuses on improving the quality of scientific information on the status of ecosystems and the impacts of particular fishery management approaches on ecosystems. Several participants suggested that the PFRP could play an important role by supporting highly targeted data collection projects to assist in validation of ecosystem models. Many participants spoke to the gap or disconnect between scientific investigation and communication of results and implications to the broader public. Although there was broad recognition about the need for an honest broker to accurately summarize and convey research findings to the broader public, participants did not view this as an appropriate PFRP function.

Development of ecosystem assessment models is essential to estimate the impacts of ecosystems on fisheries and the behavior of pelagic fish. **Participants emphasized that despite the ecosystem focus, single species stock assessments are essential.**

8. Linkages Among Research Topics

Participants recognized that there are numerous potential linkages between research topics and also that some topics might more appropriately be split.

8.1 Across Breakout Group Subject Areas

- Combine Applied Economics topic 2 (use economic tools to examine socioeconomic constraints to indigenous fisheries) and Fishing Communities topic 4b (identify fishing community objectives/hopes for access to fishery resources).
- Add concept of "bio-economic modeling" to the list of biological and physical modeling in Applied Economics topic 1.
- Add "markets" to Fishing Community topic 1 description of fish flow. This will help expand this topic beyond the local level to regional/basin-wide levels, thereby linking this topic with several economic topics.

8.2 Within Breakout Group Subject Areas

- Link Biology and Life History topic 2 (investigation of trophic ecology of tuna and related species) and topic 3 (physiological research on tuna and related species). Both provide important information for ecosystem modeling.
- Combine Ecosystem Integration topics 2 (focused on determining the effects of FADs on local and wider scales) and 15 (determine the importance of the scale of interactions on the way ecosystems adapt to change on local and basin scales).
- Link Ecosystem Integration topic 9 (development of ecosystem indicators) with Ecosystem Integration topic 3 (study movement to define functional sizes of ecosystem units) and 6a (influence of meso-scale oceanography on ecosystems). Indicators need to link to functional sizes.
- Combine Ecosystem Integration topics 4b and 6b, as they both concern impacts on protected species.
- Biology and Life History topic 1 involves several issues including an international tagging program, establishment of a major tissue archive, development of tagging methods, and assessment of long-term basin scale movement and influence of biological and oceanographic features.

9. Potential Omissions to be Addressed

Participants mentioned several key research areas that may not have received sufficient attention or discussion during the breakout sessions.

- Genetics-related projects. Some important topics seem to be missing (e.g., the application of genetics to determination of sex and movement). This omission may be a reflection of under-representation of geneticists at the workshop.

- Economic value of keeping fishing data confidential. How valuable are these data to competitors? Can economics be applied to determine how valuable confidential catch and effort data are? What are the tradeoffs for sharing these data (how would this help or hurt fishers)?

Participants noted the importance of past information for interpreting current state of the fishery and fish populations. Discovery, preservation, and analysis of old samples and data should be given high priority. The discussion extended the notion of "data rescue" to include "tissue sample rescue." There was considerable support for the notion of establishing a tissue archive.

10. Coda

The workshop concluded on November 18 with a consensus that research in support of management for highly migratory fish stocks requires a basin-scale approach based on fundamental understanding of the pelagic ecosystem. Earlier on the same day, the United States Senate gave its advice and consent to two critical international fisheries agreements: the Convention on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, with Annexes (the "WCPF Convention"), which was adopted at Honolulu on September 5, 2000, by the Multilateral High Level Conference on Highly Migratory Fish Stocks in the Western and Central Pacific Ocean; and the Convention for the Strengthening of the Inter-American Tropical Tuna Commission established by the 1949 Convention between the United States of America and the Republic of Costa Rica, with Annexes, (the "Antigua Convention"), which was adopted on June 27, 2003, in Antigua Guatemala, by the Parties to the 1949 Convention. The Senate's actions pave the way for the United States to be a full participant in the fishery management organizations created by these two treaties. The two commissions jointly have the potential to regulate fisheries of highly migratory species in a harmonized regime consistent with modern fishery management goals, including the ecosystem approach. In addition, the Western Pacific Regional Fishery Management Council has adopted a Fishery Ecosystem Plan for the pelagic fisheries under Council jurisdiction. Thus the PFRP will have no shortage of clients for its research products.

11. References

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12. Appendix A. Breakout Session Organization and Flow

Each of the breakout sessions was supported by a session moderator responsible for directing the technical deliberations, a facilitator responsible for managing the discussion and capturing notes on flipcharts, and a note-taker responsible for recording comments in a computer.

1. Applied economics: economics applied to the development of fishery management policy. Sam Pooley, moderator; Scott McCreary, facilitator; Blake McNaughton, recorder.
2. Ecosystem integration: including a focus on the areas of incidental catch and protected species, ecosystem delineation and indicators, oceanography, and modeling. Chris Boggs, moderator; Eric Poncelet, facilitator; Robert Skillman and Peter Ajtai, recorders.
3. Biology and life history: application of biology and life history studies to the development of fishery management policy. Paul Dalzell, moderator; Scott McCreary, facilitator; Pater Ajtai, recorder.
4. Fishing communities: informing fisheries management through understanding of fishing communities. Craig Severance, moderator; Eric Poncelet, facilitator; Blake McNaughton, recorder.

12.1 The Breakout Session Flow

1. Brainstorm potential research topics. Participants spent a significant portion of the breakout group activity brainstorming potential PFRP research topics seen as important and salient for addressing pelagic fisheries management needs. These discussions built on the research and management needs described during the Day 1 morning presentations.
2. Consolidate potential research topics into a commonly understood list. Once participants had completed brainstorming potential research topics, the facilitators worked with breakout group members to consolidate the topics into a more concise list.
3. Rank candidate research topics. Participants were given the opportunity to show preference for the individual research topics discussed within their breakout sessions by participating in a ranking exercise. The ranking strategy assumed that the invited participants represented a reasonable cross section of the research and policy community, and that the summation of their preferences would represent a reasonable assessment of research priorities.
    - Participants were allocated a specific number of "dots" to use in each ranking. The number of dots was generally keyed to the number of items to be ranked.
    - Participants were invited to "spend" their dots by placing them next to the research topics that they viewed as most "important and salient for addressing pelagic fisheries management needs." Participants could express level of preference by allocating more than one dot to a particular research topic (up to a maximum of 3 to 5 dots per topic, depending on the number of items to be ranked).

- Once each participant had voted, the facilitator, note-taker, and moderator teamed to tally the results. Facilitators then posted the topics in ranked order, listing the number of "dot votes" received.

While most workshop participants agreed to go forward based on this working assumption, some voiced the view that rankings based on this system of voting would merely reflect the opinions of those who participated in the process and would therefore not be universal. As the meeting progressed, nearly all participants chose to take part in the ranking exercise. The complete list of priority topics, rankings and vote scores are included in Appendix B.

13. Appendix B. Ranked Lists of Research Items

The tables below present the lists of research items identified and ranked in each breakout group. Each item is identified by its rank so that item #1 is the item in each table that received the largest number of votes by the participants in the breakout session. Topics with equal numbers of votes are distinguished by letters.

13.1 Applied Economics—Session 1

Rank (Topic #)	Topic	Votes
1	Continue investigation of a broad range of economic models, including I/ABMs, RUMs, programming, and experimental models, to identify efficient methods for evaluating policy choices.	31
2	Use economic tools to examine socioeconomic constraints to indigenous fisheries.	30
3	Identify a comprehensive ecosystem framework for economic analysis, including integration with biological and physical modeling.	29
4a	Generate detailed information on non-commercial fishing sectors. This includes expenditures, non-market values, sectoral linkages, and unsold portion of catch.	27
4b	Provide timely data in template formats. Includes thorough documentation, STD variable, names, GIS references, etc.	27
5	Enhance I/O approaches to the overall contribution of the fisheries sector to the Pacific economy including social accounting, non-market aspects, etc.	25
6	Create easily updatable and malleable models for management applications. This includes tractable versions of all models.	23
7	Undertake regular analyses of global and regional market influences on local seafood markets to anticipate large scale and regulatory impacts on local fisheries.	21
8	Investigate consumer preference formation, including sensitivity to source, environmental sustainability, seafood safety, etc.	20

13.2 Ecosystem Integration—Session 2

Rank (Topic #)	Topic	Votes
1	Evaluate large-scale trophic interactions such as removal of specific tuna species with the goal to address impact of fishing on ecosystems.	38
2	Determine effects of FADs on local and wider-scale ecosystems and on pelagic fish production.	36
3	Study movement to define functional sizes of ecosystem units.	33
4a	Develop ecosystem process-based models that provide stock assessment.	32
4b	Explore methods to reduce bycatch, including protected species.	32
4c	Improve stock assessment methods.	32
5	Carry out ecosystem/multi-species management strategy evaluation. Potentially include data collection, control rules, monitoring, and assessment methods.	31
6a	Determine the influence of meso-scale oceanography (fronts, eddies, seamounts) on ecosystems.	28
6b	Assess fishery and non-fishery impacts on protective/sensitive species, and vice versa.	28
7a	Assess the relative importance of epi- and meso-pelagic prey organisms on structuring trophic interactions.	26
7b	Conduct education/outreach of scientists, managers, and public, including tech cross-fertilization and tool sharing across disciplines.	26
8	Determine impact of climate variability/changes.	24
9	Simplify complexity through use of ecosystem indicators (such as community trophic level, diversity, etc.).	22
10	Determine how good an ecosystem model needs to be to provide better advice than species-based models.	16
11	Evaluate the role of pollutants on marine ecosystems.	15
12	Apply fishery management tools to address non-target impacts.	13
13	Establish Pacific science community network to explore standardization of information systems and reference points.	9
14	Define/investigate key data inputs and key species needed for ecosystem models.	8
15	Determine the importance of the scale of interactions on the way ecosystems adapt to change on local and basin-scales.	7
16	Evaluate ecosystem impacts from aquaculture.	3

13.3 Biology and Life History—Session 3

Rank (Topic #)	Topic	Votes
1	Support the development of a major international tagging program. This includes establishment of a major tissue archive and development of chemical and electronic tagging methods. This includes assessment of long-term basin scale movement and influence of oceanographic and biological features (e.g., currents, seamounts).	86
2	Support investigations of trophic ecology of tuna and related species. This includes identification of keystone prey and spatial differences in forage base.	70
3	Support physiological research on tuna and related species to improve understanding of energetics and the parameterization of ecological models.	61
4	Support investigations into existing and novel techniques for age and growth of tunas and related species, this includes examining hard parts and biochemical methods.	50
5	Support research to improve understanding of reproduction. This includes spatial differences in size and age at maturity, spawning seasons, spawning locations, fecundity, etc.	48
6	Support investigations to improve understanding of associations between tunas and other marine animals. This includes studies of whale sharks and cetaceans.	37
7	Support investigation of early life history of tuna and other sensitive marine species.	36
8	Support investigation on of the effect of closed areas as management tool. This includes movement mixing depletion of target species (and associated species).	32
9	Support other investigations to improve understanding of behavior with respect to fishing gear to improve targeting.	22

13.4 Fishing Communities—Session 4

Rank (Topic #)	Topic	Votes
1	Determine fish flow, including sources, distribution channels, quantities, and end use (including cultural value).	26
2	Study stakeholder/public perceptions of conditions of pelagic fisheries and their impacts on the marine ecosystems (including the basis for these perceptions).	20
3	Contextualize fishery data (catch, CPUE, bycatch) in terms of social (e.g., culture), ecological (e.g., storms), economic/market, and political, and technological history.	16
4a	Identify additional uses of MRFSS/HMRFSS/Creel surveys and data (including small scale independent validation for MRFSS), and encourage linkages with other research projects.	15
4b	Identify fishing community objectives/hopes for access to fishery resources.	15
4c	Study at-sea fleets as communities (including expert knowledge, and fishery behavior).	15
5	Assess impacts of regulations on fishermen and associated communities (looking back) [e.g., Was NEPA/SIA analysis predictive?].	10
6	Identify non-commercial user groups with respect to registration (including identifying attitudes toward registration/reporting).	5
7	Evaluate effectiveness of collaborative resource management groups (i.e., what makes a group effective or ineffective?).	4
8	Assess application of social science models as decision support tools for fishery management.	3
9	Compile research findings of human dimensions research in the region.	1

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15. Appendix D: List of Acronyms

BET	Bigeye tuna
CPUE	Catch per unit of effort
EEZ	Exclusive Economic Zone
EPO	Eastern Pacific Ocean
FAD	Fish Aggregating Device
FMP	Fishery Management Plan
IATTC	Inter-American Tropical Tuna Commission
MSY	Maximum Sustainable Yield
NOAA	National Oceanic and Atmospheric Administration
NRIFSF	National Research Institute of Far Seas Fisheries
OFP	Oceanic Fisheries Programme
PFRP	Pelagic Fisheries Research Program
PIT	Passive Integrative Transponder
PIFSC	Pacific Islands Fisheries Science Center
PNG	Papua New Guinea
SKJ	Skipjack tuna
SPC	Secretariat of the Pacific Community
UH	University of Hawaii
WCPFC	Western and Central Pacific Fisheries Commission
WPRFMC	Western Pacific Regional Fishery Management Council
YFT	Yellowfin tuna

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